MOVING OBJECT DETECTION USING CELLULAR NEURAL NETWORK (CNN)

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This thesis is submitted as partial fulfillment of the requirements for the award of the
Bachelor Degree of Electrical Engineering (Control and Instrumentation)

Faculty of Electrical & Electronics Engineering
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NOVEMBER, 2008

"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Control and Instrumentation)"

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Specially dedicated to
my beloved parents and best friends for their full support
and love throughout my journey of education.

ACKNOWLEDGEMENT

I would like to thank my parents for their love, support and patience during the year of my study. I also would like to take this opportunity to express my deepest gratitude to my supervisor, En Amran bin Abdul Hadi for his patience and guidance in preparing this paper. Special thanks to all my friends who have directly or indirectly have contributed to my success in completing this thesis. Last but not least, I would like to thank God for being within me.

ABSTRACT

Detecting moving objects is a key component of an automatic visual surveillance and tracking system. Previous motion-based moving object detection approaches often use background subtraction and inter-frame difference or three-frame difference, which are complicated and takes long time. In this paper, we proposed a simple and fast method to detect a moving object using Cellular Neural Network. The main idea in Cellular Neural Network is that connection is allowed between adjacent units only. This paper comprises the implementation of the basic templates available in Cellular Neural Network. The templates are programmed in MATLAB. There are few rules in Cellular Neural Network that has to be implemented when programming the templates, such as the state equation, output equation, boundary condition and also the initial value. These templates are combined to create the most ideal algorithm to detect a moving object in an image. A video of a bouncing ball is recorded using a static camera. The video then are segmented into images using SC Video Developer. Ten images are selected to be used in this project. The algorithm created is used to detect the ball in the images. This paper also includes the use of Image Processing Toolbox in MATLAB. An analysis is conducted by comparing the ball's position in each image according to the time. This analysis indicates whether the object has shifted position or moved in the images. The efficiency of the result for this paper is 85%.

ABSTRAK

Mengesan pergerakan objek ialah satu komponen yang penting dalam sistem pengawasan automatik dan sistem pengesanan pergerakan. Kaedah pengesanan pergerakan objek yang sedia ada sering menggunakan cara penyingkiran latar belakang dan perbezaan antara lapisan di mana kaedah tersebut rumit dan mengambil masa yang lama. Untuk projek ini, kaedah yang lebih mudah dan pantas dicadangkan untuk mengesan pergerakan objek dengan menggunakan Cellular Neural Network. Sifat Cellular Neural Network yang utama ialah kebolehan sel-sel bersebelahan atau setempat berkomunikasi atau berinteraksi dengan sel-sel jiran. Projek ini mengaplikasikan model klon asas yang terdapat di dalam Cellular Neural Network. Model klon tersebut diprogramkan dengan menggunakan perisian MATLAB. Terdapat beberapa peraturan yang harus diambil kira dan dipatuhi semasa membuat pemprograman untuk model klon seperti persamaan keadaan, persamaan hasil, keadaan sempadan dan nilai awal. Model-model klon yang dihasilkan digabungkan bersama untuk mencipta satu algoritma yang sesuai untuk mengesan pergerakan objek di dalam imej. Satu rakaman video yang menunjukkan pergerakan bola yang melantun direkodkan dengan menggunakan kamera statik. Rakaman video ini kemudian disegmentasikan dengan menggunakan perisian SC Video Developer. Sepuluh imej dipilih untuk digunakan dalam projek ini. Algoritma yang dicipta digunakan untuk mengesan pergerakan bola dalam imej-imej tersebut. Projek ini juga mengaplikasikan Image Processing Toolbox yang terdapat di dalam perisian MATLAB. Analisis yang menunjukkan perbandingan kedudukan atau koordinat bola di dalam imej-imej tersebut dihasilkan. Tahap ketepatan keputusan untuk projek ini ialah 85%.

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CHAPTER I

INTRODUCTION

1.1 Overview

Moving object detection is always an important task in this world of technology. Moving object detection plays an important role in automatic visual surveillance, tracking system and also to avoid collision.

Cellular Neural Network was invented by Leon O. Chun and Lin Yang in Berkeley in 1988. In Cellular Neural Network, the time is continuous and the interaction values are real values. Each processing cell interacts or communicates with its nearest neighbouring cells through a program or an algorithm. Cells are only connected within a certain neighbourhood but not to the entire network, thus it is easy for extension without readjusting the whole network. Due to this, Cellular Neural Network can be used in applications such as high speed target recognition, real-time visual inspection of manufacturing process and also any brain-like information processing tasks.

This thesis implements the basic templates from Cellular Neural Network in creating an algorithm using MATLAB as the programming platform. The process starts by recoding a moving ball or bouncing ball video using stationary camera. Then, the images are edited using Image Processing Toolbox in MATLAB. Templates are created using MATLAB and then an ideal algorithm is selected to detect the moving object. An analysis comparing the object previous and new position is done.

1.2 Objectives

The objectives of this program are:

i. To understand the concept of Cellular Neural Network and its application.
In this project, the concept of Cellular Neural Network must be understood in order to apply it. The concept of Cellular Neural Network is its characteristic and the way it works in certain condition. The characteristic of Cellular Neural Network is elaborated in detail in the literature review. Cellular Neural Network has a lot of applications and it can be used in most of electric and electronic projects instead of the traditional methods used before.

ii. To detect a moving object captured by static camera using an algorithm developed in Cellular Neural Network.
In this project, the main idea is to detect the moving object or the motion of an object. A static camera will capture or in another word, record a moving object. The moving object is then detected using Cellular Neural Network. In detail, an algorithm is developed using Cellular Neural Network templates which can be used to detect a motion. This algorithm is actually a combination of several templates available in Cellular Neural Network. This templates and its application is explained in the literature review.

1.3 Scope

i. An algorithm is developed based on templates in Cellular Neural Network and simulates the programming in MATLAB to detect moving object.
An algorithm is developed using the templates in Cellular Neural Network. This algorithm is applied through MATLAB to detect a moving object. The programming is done is MATLAB and by simulating the programming, the moving object will be detected.

ii. An analyze of the object's positions in the images according to the time.
To make image segmentation and analyze the object's position in each images using MATLAB. The object is identified using coordinate system. A comparison of the object's previous and current coordinates will be done to indicate the movement of the object in the images.

1.4 Problem Statement

i. Moving object detection requires real time processing, which is fast, thus Cellular Neural Network is excellent choice as it is a parallel paradigm which provides fast processing.

ii. Compared to existing method, such as spatio-temporal constraints, it takes longer time to detect moving object and more complicated than Cellular Neural Network.

1.5 Thesis Outline

This thesis consists of five chapters. Chapter I cover on the introduction of the project, objectives of project, scopes of project and also the problem statement. Chapter II is mainly about the literature review done for this project. This chapter discusses the Cellular Neural Network, its basic notation and definitions, application of Cellular Neural Network in different areas, and also the main or basic templates in Cellular Neural Network. Chapter III focuses on the methodology for the whole project and also methodology on the Cellular Neural Network template programming architecture. Chapter IV shows the results obtained from this project, analysis and also the discussion. The last chapter, Chapter V consists of the conclusion of the project, recommendation for further development and also cost and commercialization of this project.

CHAPTER II

LITERATURE REVIEW

2.1 Cellular Neural Network

Cellular Neural Network is also known as Nonlinear Neural Network or CNNs. The Cellular Neural Network was invented by Leon O. Chua and Lin Yang in Berkeley in 1988. Cellular Neural Network is an array of analog dynamic processors or cells. Cellular Neural Network host processors accept and generate analog signals. Other than that, the interaction values are also real values. Moreover, the input of the Cellular Neural Network array plays an important role as Cellular Neural Network becomes rigorous framework for complex systems exhibiting emergent behavior and the various forms of emergent computations.

The Cellular Neural Network Universal Chip is a milestone in information technology because it is the first operational, fully programmable industrial-size brain-like stored-program dynamic array computer in the world. Each Cellular Neural Network cell is interfaced with its nearest neighbours and this massively parallel focal-array computer is capable of processing 3 trillion equivalent digital per operations per second (in analog mode), a performance which can be matched only by supercomputers. In terms of SPA (power, speed, area) measures, this Cellular Neural Network Universal chip is far superior to any equivalent DSP implementation by at least three orders of magnitude. The applications include high-speed track target recognition and tracking, real-time visual inspection of manufacturing processes, intelligence vision capable of recognizing context sensitive and moving scenes, as well as applications requiring real-time fusing of multiple modalities, such as multispectral images involving visible, infrared, long-wave infrared, and polarized lights [1].

Cellular Neural Network is a parallel computing paradigm defined in discrete N-dimensional spaces. Cellular Neural Network is an N-dimensional regular array of elements or cells. A standard Cellular Neural Network architecture consists of an M x N rectangular cells (C(i, j)) with Cartesian coordinates (i, j). The cell grid can be for example, a planar array with rectangular, triangular or hexagonal geometry, a 2-D or 3-D torus, a 3-D finite array, or a 3-D sequence of 2-D arrays. Cells are multiple input-single output processors, all described by one or just some few parametric functional. A cell is characterized by an internal state variable, sometimes not directly observable from outside the cell itself. More than one connection network can be present, with different neighbourhood sizes.

Cellular Neural Network is a system of cells defined on a normalized space. In the system, cell is the basic circuit unit containing linear and nonlinear circuit element, which are linear capacitors, linear resistors, linear and nonlinear controlled sources and independent sources. The main idea is that the connection is allowed between adjacent units only. Any cell in the Cellular Neural Network is connected to only its neighbour cells. But cells can affect each other indirectly. The propagation effects of the continuous time dynamics of the Cellular Neural Network provides the interaction between cells in space.

A Cellular Neural Network dynamical system can operate both in continuous (CT-CNN) or discrete time (DT-CNN). Cellular Neural Network data and parameters are typically continuous values. Cellular Neural Network operate typically with more than one iteration, they are recurrent networks. Cellular Neural Network main characteristic is the locality of the connections between the units. In fact the main difference between Cellular Neural Network and other Neural Networks paradigms is the fact that information is directly exchanged just between neighbouring units. This characteristic allows also obtaining global processing. Communications between non directly (remote) connected units are obtained passing through other units.

It is possible to consider the Cellular Neural Network paradigm as an evolution of Cellular Automata paradigm. Moreover it has been demonstrated that Cellular Neural Network paradigm is universal, being equivalent to the Turing Machine.

2.2 Basic Notations and Definition

2.2.1 Standard CNN architecture

A standard CNN architecture consists of an M × N rectangular array of cells (C(i, j)) with Cartesian coordinates (i, j), i = 1, 2,…M, j = 1, 2…N

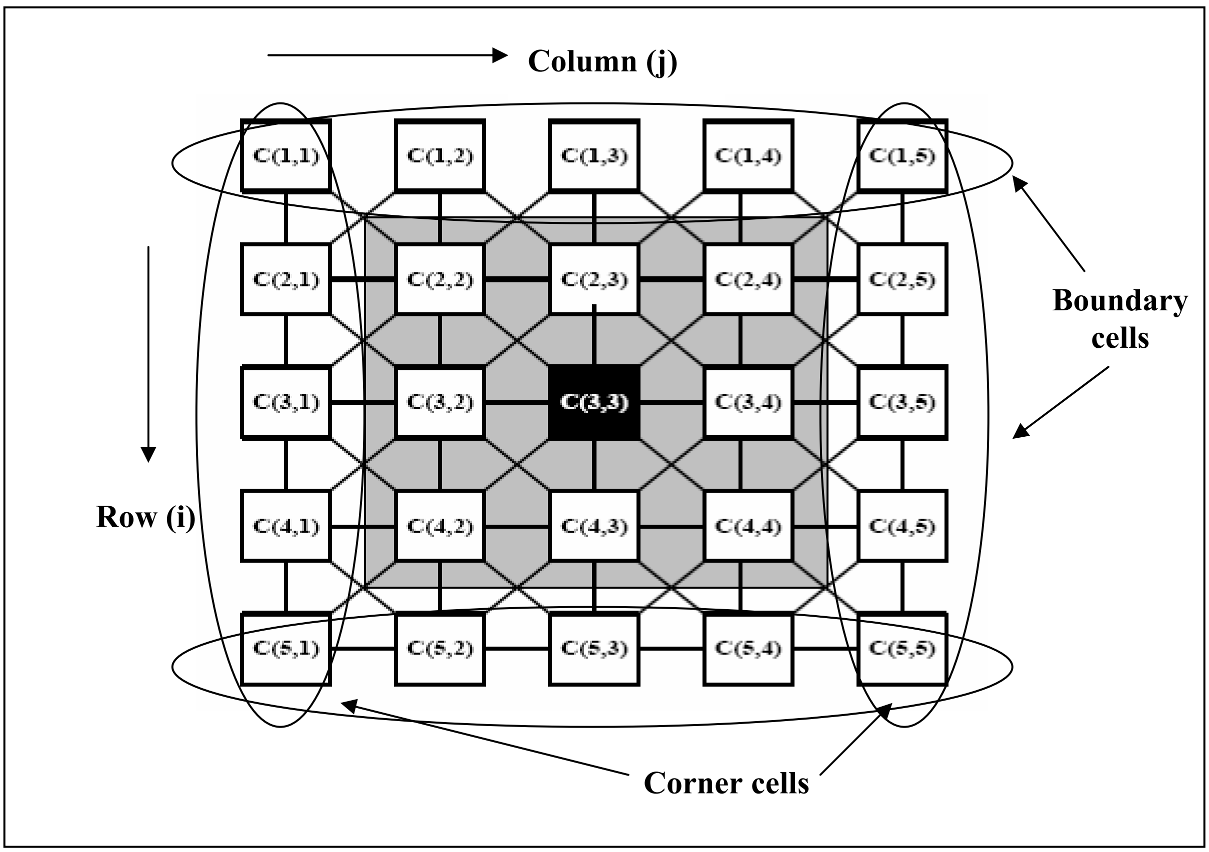

Figure 2.1: Standard CNN 5 X 5 Architecture

2.2.2 Sphere of Influence of Cell C(i, j)

The sphere of influence, Sr(i, j), of the radius r of cell C(i, j) is defined to be the set of all the neighbourhood cells satisfying the following property.

$$Sr(i,j) = \{C(k,l) \mid \max\{|k-i|, |l-j|\} \leq r\}$$
$$1 \leq k \leq M, 1 \leq l \leq N$$

where r is a positive integer

2.2.3 Regular and Boundary Cells

A cell C(i, j) is called regular cell with respect to Sr(i, j) if and only if all neighbourhood cells $C(k,l) \in Sr(i,j)$ exist. Otherwise, C(i, j) is called a boundary cell.

2.2.4 Standard CNN

A class 1 M × N standard CNN is defined by M × N rectangular array of cells C(i,j) located at side (i, j), i = 1, 2,…M, j = 1, 2…N. Each cell C(i, j) is defined mathematically by:

Definition 1: State equation

$$\dot{x}ij = -xij + \sum_{C(k,l) \in Sr(i,j)} \mathrm{A}(i,j;k,l)ykl + \sum_{C(k,l) \in Sr(i,j)} \mathrm{B}(i,j;k,l)ukl + \mathrm{Z}ij$$

where $xij \in R$, $ykl \in R$, $ukl \in R$ and $Zij \in R$ are called state, output, input and threshold of cell C(i, j) respectively. $A(i, j; k, l)$ and $B(i, j; k, l)$ are called the feedback.

Definition 2: Output equation

$$yij = f(xij) = \frac{1}{2}|\, xij + 1\,| - \frac{1}{2}|\, xij - 1\,|$$

This is called the standard nonlinearity.

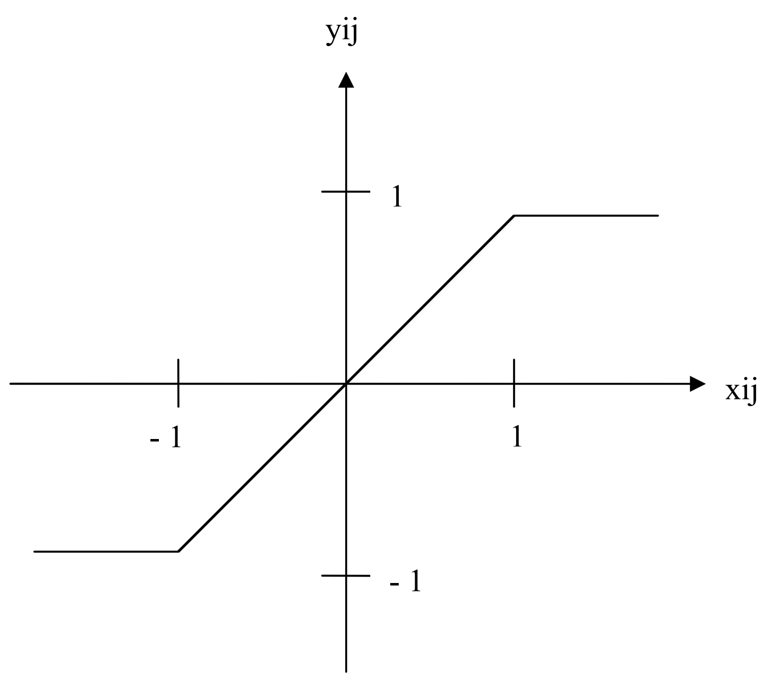

Figure 2.2: Standard Nonlinearity

Definition 3: Boundary Conditions

The boundary conditions are those specifying ykl and ukl for each cells belonging to $Sr(i, j)$ of edge cells but lying outside of M x N array.

Definition 4: Initial state

$$xij(0), \qquad i = 1,\ldots,M, \quad j = 1,\ldots,N$$

2.3 Applications

There are many applications of Cellular Neural Network especially in healthcare. For example, Cellular Neural Network is used in clinical diagnosis known as Papnet. Papnet is a commercial Cellular Neural Network based computer program for assisting screening of Pap (cervical) smears. In this Pap smear test, cells taken from uterine cervix are examined for signs of precancerous and cancerous changes. If detected early, cervical cancer has an almost 100% chance of cure. The traditional method, which is relying on human eyes to detect abnormal cells under microscope, has difficulty in detecting cancer in early stage. Since a patient with a serious abnormality can have fewer than a dozen abnormal cells among the 30,000 - 50,000 normal cells on her Pap smear, it is very difficult to detect all cases of early cancer by this "needle-in-a-haystack" search [2]. Using Cellular Neural Network results in more accurate screening process thus, leading to an earlier and more effective detection of pre-cancerous cells in the cervix.

Other than that, Cellular Neural Network is also used in image analysis and interpretation particularly in medicine. Pattern recognition is widely used to identify and extract important features in radiographies, ECTs or MRIs. Filtering, segmentation and edge detection techniques using Cellular Neural Network improves resolution in brain tomographies, and also improves global frequency correction for the detection of microcalcifications in mammograms. Furthermore, under healthcare, Cellular Neural Network is also used in signal analysis and interpretation and drug development.

Cellular Neural Network is also used in other applications beside healthcare. For instance Cellular Neural Network is used in lip reading. The three main parts of the system include a face tracker, lip modeling and speech processing. Automatic speech reading is based on a robust lip image analysis. The analysis is based on truecolor video images. The system allows for real-time tracking and storage of the lip region and robust off-line lip model matching. A neural classifier detects visibility of teeth edges and other attributes. At this stage of the approach, the edge closed lips is automatically modeled if applicable is based on neural network's decision.

To achieve high flexibility during lip-model development, a model description language has been defined and implemented. The language allows the definition of edge models (in general) based on knots and edge functions. Inner model forces stabilize the overall model shape. User defined image processing functions may be applied along the model edges. These functions and the inner forces contribute to an overall energy function. Adaptation of the model is done by gradient descent or simulated annealing like algorithms.

Another application of Cellular Neural Network is detecting and tracking of moving targets. The moving target detection and track methods here are "track before detect" methods. They correlate sensor data versus time and location, based on the nature of actual tracks. Compared to conventional fixed matched filter techniques, these methods have been shown to reduce false alarm rates by up to a factor of 1000 based on simulated SBIRS data for very weak ICBM targets against cloud and nuclear backgrounds, with photon, quantization, and thermal noise, and sensor jitter included.

The methods are designed to overcome the weaknesses of other advanced track-before-detect methods, such as 3+-D matched filtering, dynamic programming (DP), and multi-hypothesis tracking (MHT). Loosely speaking, 3+-D matched filtering requires too many filters in practice for long-term track correlation. DP cannot realistically exploit the non-Markovian nature of real tracks, and strong targets mask out weak targets, and MHT cannot support the low pre-detection thresholds required for very weak targets in high clutter. They have developed and tested versions of the above (and other) methods in their research, as well as Kalman-filter probabilistic data association (KF/PDA) methods, which they use for post-detection tracking. Space-time-adaptive methods are used to deal with correlated, non-stationary, non-Gaussian clutter, followed by a multi-stage filter sequence and soft-thresholding units that combine current and prior sensor data, plus feed back of prior outputs, to estimate the probability of target presence.

Cellular Neural Network is also used in real-time target identification based for security application. The system localizes and tracks peoples' faces as they move through a scene. It integrates the techniques such as motion detection, tracking people based upon motion and tracking faces using an appearance model. Faces are tracked robustly by integrating motion and model-based tracking. Cellular Neural Network is also used in ATM network, noise reduction, finger print match, face recognition, biomedical and word sporting.

High speed detection and classification of the objects, symbols, and characters with an acceptable error rate is a task which is always considered when new computing architecture, suitable for image processing and pattern recognition. In Cellular Neural Network concept, the research area of these is locally connected, regularly repeated analog arrays have shown remarkable growth. Recently, based on the Cellular Neural Network paradigm, a universal hardware architecture has been designed, called the Cellular Neural Network Universal Machine. This new algorithmically programmable analog array computer is an ideal environment for "dual computing" for example to execute complex Cellular Neural Network analogic algorithms. In these algorithms, analog operations which are controlled by various Cellular Neural Network templates are combined with local logic on the cell level. Using this concept, complex decisions can be made on images without reading out the Cellular Neural Network chip which makes this method extremely time effective.

2.4 Templates

Different role of the control and feedback matrices in Cellular Neural Network templates is also applied to detect motion. In the past few years, several researchers also attempted character recognition by incorporating the Cellular Neural Network concept. T. Matsumoto presents some simple Cellular Neural Network templates for binary image processing. Later, these templates (horizontal, vertical, diagonal CCD and Shadow Detector) were used by Suzuki to introduce a new character recognition method by Cellular Neural Network preprocessing and a back propagation classification. T. Szirányi and J. Csicsvári completed the above mentioned templates by the Hole-Filler one and used a novel type of CNND architecture. K. Nakayama and Y. Chigawa used CNN for extracting line segment features (middle point, length and angle of the line segment) and for character recognition combined it with modified self-organizing feature mapping. Most of them turned out to be very efficient in recognition of distorted and translated patterns.

Each template has its own feedback, input synaptic, threshold values, boundary conditions and initial states that need to be fulfilled to obtain the results. The input and threshold are continuous functions of time according to the uniqueness theorem.

2.4.1 EDGE: Binary Edge Detection Template

A =

0	0	0
0	0	0
0	0	0

B =

-1	-1	-1
-1	8	-1
-1	-1	-1

z =

-1

Global Task

Given : static binary image **P**

Input : **U**(t) = **P**

Initial state : **X**(0) = Arbitrary (in examples we choose $x_{ij}(0) = 0$)

Boundary conditions : Fixed type, $u_{ij} = 0$, $y_{ij} = 0$ for all virtual cells, denoted by **[U]** = **[Y]** = [0]

Output : **Y**(t) $\Rightarrow$ **Y**(∞) = Binary image showing all edges of **P** in black

Remark

The Edge CNN template is designed to work correctly for binary input images only. If **P** is a gray-scale image, **Y**(∞) will be in general be gray-scale where black pixels correspond to sharp edges, near-black pixels correspond to fuzzy edges, and near-white pixels correspond to noise.

2.4.2 CORNER: Convex Corner Detection Template

A =

0	0	0
0	2	0
0	0	0

B =

-1	-1	-1
-1	8	-1
-1	-1	-1

z = $\boxed{-8.5}$

Global Task

Given : static binary image **P**

Input : **U**(t) = **P**

Initial state : **X**(0) = 0

Output : **Y**(t) $\Rightarrow$ **Y**(∞) = Binary image, where black pixels correspond to convex corners in **P** (where, roughly speaking, a black pixel is a convex corner if it is a part of a convex corner boundary line of the input image).

2.4.3 LOGNOT: Logic NOT and set complementation ($P \rightarrow \overline{P} = P^c$) template

A =

0	0	0
0	1	0
0	0	0

B =

0	0	0
0	-2	0
0	0	0

z = $\boxed{0}$

Global Task

Given	: static binary image **P**
Input	: **U**(t) = **P**
Initial state	: **X**(0) = 0
Output	: **Y**(t) $\Rightarrow$ **Y**(∞) = Binary image where each pixel in **P** becomes white, and vice versa. In set-theoretic or logic notation: **Y**(∞) = $P^c = \overline{P}$, where the bar denotes the "Complement" or "Negation" operator.

2.4.4 LOGOR: Logic OR and set union $\cup$ (disjunction $\vee$) template

A =

0	0	0
0	3	0
0	0	0

B =

0	0	0
0	3	0
0	0	0

z =

2

Global Task

Given : two static binary image $\mathbf{P}_1$ and $\mathbf{P}_2$

Input : $\mathbf{U}(t) = \mathbf{P}_1$

Initial state : $\mathbf{X}(0) = \mathbf{P}_2$

Output : $\mathbf{Y}(t) \Rightarrow \mathbf{Y}(\infty)$ = Binary output of the logic operation **OR** between $\mathbf{P}_1$ and $\mathbf{P}_2$. In logic notation, $\mathbf{Y}(\infty) = \mathbf{P}1 \vee \mathbf{P}2$, where $\vee$ denotes the "disjunction" operator. In set-theoretic, $\mathbf{Y}(\infty) = \mathbf{P}1 \cup \mathbf{P}2$, where $\cup$ denotes the "set union" operator.

2.4.5 LOGAND: Logic AND and set intersection $\cap$ (conjunction $\wedge$) template

A =

0	0	0
0	1.5	0
0	0	0

B =

0	0	0
0	1.5	0
0	0	0

z =

-1.5

Global Task

Given : two static binary image $\mathbf{P}_1$ and $\mathbf{P}_2$

Input : $\mathbf{U}(t) = \mathbf{P}_1$

Initial state : $\mathbf{X}(0) = \mathbf{P}_2$

Output : $\mathbf{Y}(t) \Rightarrow \mathbf{Y}(\infty)$ = Binary output of the logic operation **"AND"** between $\mathbf{P}_1$ and $\mathbf{P}_2$. In logic notation, $\mathbf{Y}(\infty) = \mathbf{P}_1 \wedge \mathbf{P}_2$, where $\wedge$ denotes the "conjunction" operator. In set-theoretic notation, $\mathbf{Y}(\infty) = \mathbf{P}_1 \cap \mathbf{P}_2$, where $\cap$ denotes the "intersection" operator.

2.5 Moving Object Detection

Identifying moving object is a critical task in image and video segmentation, which is used in many computer vision applications such as remote sensing, video surveillance and traffic monitoring. In the research done, there are some common methods used to detect a moving object. One of the popular methods is using spatio-temporal constraints.

In spatio-temporal constraints method, there are many steps to be done before we can actually detect the object. Steps such as background removal or background subtraction, colour analysis, image depth, and object's shape analysis are necessary. Spatio-temporal databases deal with objects that change their location or shape over time. A typical example of spatio-temporal databases is moving objects in the D-dimensional space. Moving objects learn about their own location via location detection devices, such as GPS devices. Then, the objects report their locations to the server using the underlying communication network, like the wireless networks. The server stores the updates from the moving objects and keeps a history of the spatio-temporal coordinates of each moving object. In addition, the server stores additional information to help predict the future positions of moving objects. As can be seen above, the spatio-temporal constraints method is very complicated as there are many steps involved.

In recent years, using Cellular Neural Network in moving object detection has gained much popularity. In the research done for moving object detection, there are many ways to detect a moving object using Cellular Neural Network. The most commonly used type of Cellular Neural Network is Delayed Cellular Neural Network and Analogic Cellular Neural Network. Delayed Cellular Neural Network was first introduced in 1993 where it involves 2-D images. Moving object detection is the most appealing task in the field of image processing. In this Delayed Cellular Neural

Network, the study was focused on two parts, first is without considering motion and the second part detection of moving object. Besides Cellular Neural Network, processing of moving images requires the introduction of delay in the signals transmitted among the cells. In the Delayed Cellular Neural Network, the delay τ is introduced in the state equation.

In the Analogic Cellular Neural Network, the ring-coding is used for detection of moving object. An object can be described by drawing a few circles around a few initial points called a central point (o) and integrating the grayness in the created rings (g1, g2, g3) according to the formula where the object is placed in the (x,y) plane. This mapping of a few real numbers leads to its rotation invariant description. But before applying the ring-coding method, there are a few rules have to be clarified such as the maximum size of object considered, the amount of rings needed for the description, and how to calculate the inner and outer radius of individual rings.

Relying on the templates and methods, a more complex Cellular Neural Network can be created to detect the colour, size and rotation shape of the object. Furthermore, the speed, direction and depth of the motion can also be classified.

CHAPTER III

METHODOLOGY

3.1 Overview of Cellular Neural Network for moving object detection

Detecting moving objects is a key component in automatic visual surveillance and tracking system. Besides that, moving object detection is also used to avoid collision. In the development of technology, moving object detection has become an important task in many different areas of application.

In this project, the most vital part is to develop the templates available in Cellular Neural Network. Then, an algorithm created from these templates is designed to detect the motion of an object, in this case, it is a bouncing ball. In order to create the programming for the algorithm, there are several other processes to be learnt beforehand. This includes the process of understanding the Cellular Neural Network and its notations, basic knowledge of image processing and also basic programming language, C or C++.

The video of a bouncing ball is recorded using stationary camera, in this project a digital camera is placed at certain point. Then, the video recorded is segmented into images or frames using SC Video Developer. These images are then used as the input for Cellular Neural Network templates. But before using it as an input, the images have to be edited using the Image Processing Toolbox. The original images are big in size and in Windows Bitmap (bmp) format.

The images are resized and changed to binary images as most of the input for Cellular Neural Network templates are binary images. The images are resized because the time taken to run the templates will be effected by the image size. Then some Cellular Neural Network templates are created for experiment. These templates include the Edge Detection Template, Convex Corner Detection Template, Logic NOT Template, Logic OR Template and Logic AND Template. But only certain templates are chosen to create the ideal algorithm. The Cellular Neural Network template are programmed considering the initial state, boundary condition, pixel value, sphere of influence, feedback synaptic, input synaptic and the threshold value.

Finally, the analysis is done by image segmentation. This image segmentation here means the segmentation of the output images from the algorithm. The object or ball in the image is identified using coordinate system to indicate any movement of the ball. As the last step of analysis, pixel counting is done to clearly show the object in the images. In this part, the pixel of the areas containing the object will be different when compared to the image background.

This chapter discusses the methodology of the project step by step from the programming of templates until the image segmentation.